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MAYFLIES FROM JAPANESE TORRENTS

IX. NOTES ON THE DISTRIBUTION *

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In ~~my~~ preceding eight papers I dealt with Japanese mayflies from the taxonomical standpoint. ~~Now~~ The ~~my~~ topic will be turned on their ecology, especially on their distribution, in this ~~paper~~ and the following ~~two~~ ~~three~~ papers.

~~I have~~ It is with great pleasure ~~in~~ that I ~~offering~~ my sincerest ~~thanks~~ to Prof. T. Kawamura, for his constant encouragement ~~and advice~~ advice and which made these reports possible. My best thanks are due to Dr. M. Ueno, ~~Otsu Hydrobiological Station, Kyoto Imperial University;~~ to Dr. H. Yuasa, Doshisha University, ~~to~~ Dr. C. Harukawa, Dr. M. Tokunaga, ~~Entomological Laboratory~~, Kyoto Imperial University, for their valuable criticisms and suggestions. ~~to whom~~ I am also indebted ~~to~~ to them for necessary instruments and literatures. Sincere thanks are extended to Messrs. M. Yamazaki, K. Okugawa, K. Iwata, T. Kani, M. Tsuda, S. Mori, S. Moishita, S. Odagaki, who have helped me in various ways.

I. Fundamentals on the distribution of mayfly nymphs.

Life form

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* Contribution from the Otsu Hydrobiological Station, Kyoto Imperial University. Contribution from the Entomological Laboratory, Kyoto Imperial University, No.

The term 'life form', which I wish to use in this study, is derived from the plant ecology. But when this term is used in the animal ecology, its meaning may be more or less modified, or extended. Animals, in general, must move about for their existence. In other words, animals have the function of moving about and in this respect ~~animals differ~~ the animal life differs from the plant life which is stationary in the occupancy ~~on~~ of the earth surface. But this function is originally defined from the general structure ~~of an animal.~~ Then, one is scarcely possible to understand the actual life of an animal from its function only, unless he considers the function of an animal together with its structure.

On the other hand, the structure itself without concidering its function is nothing but a dead body of an animal. Therefore one can not understand the real life of an animal also from its structure only. Here one needs to consider the environment of an animal ~~for the first time~~, and I should like to continue my discussion by recognizing the resultant phenomenon as a real life phenomenon that is produced ~~not only by the structure but~~ through the reaction of the structure to the environment of the animal.

In this way, the distribution of an animal is recognized as a life phenomenon and it can be treated essentially as a problem relating to the occupancy. ~~These~~ The term 'life form', which I wish to use in this study, means, more properly speaking,

the mode of life or the category of life regulated by the structure and the environment of the animal.

Similarity of life form in mayfly imagines and ~~last~~ dissimilarity of it in its nymphs

The ~~i~~imagines of mayflies from Japanese torrents are more or less similar to each other in their general appearance. It will be natural that one expects from this similarity of their structure the similarity of their habits. Indeed, the most important habit in the adult stage of the insect is the habit concerning ~~about~~ reproduction, and this may be emphasized especially in the mayflies (imagines of), as they ~~imagines~~ have only ~~the~~ atrophied mouth-parts and never take food. This similarity in their habits is easily recognized, for instance, in their nuptial flights which are common in different genera and families.

In comparison with the similarity of ~~the~~ structure in the imagines, the nymphal structure of mayflies is very different in different genera and families. ~~From~~ From, what cause does this dissimilarity originate? Here we must turn our attention to the environment of the nymphal life if we wish to solve this question. Mayfly-nymphs dwell in the fresh water, or their lives are maintained in the fresh water as the medium. But they are in their habits not free-swimming animals in the strict sense such as most fishes. They are all bottom dwellers, so they constitute a part of the bottom-fauna in various types of the

inland water, including the lake, the river, the spring, etc., but are especially important constituents in the bottom of the torrent.

How do they live their nymphal lives in such a situation? They are not sedentary. They move about, firstly, owing to the fact that they must ~~take~~ get necessary food for their development, for their transformation and finally for their reproduction. Secondly, they must escape from their enemies which ~~take~~ catch them as their own food, though this may be the negative side for existence. And these are two principles for existence which should be recognized before the life form of any animal is discussed.

Substratum and occupancy of it by mayfly nymphs

~~Their~~ Mayfly nymphs as bottom dwellers must succeed in their occupancy of the substratum for their existence, or for securing food and escaping from enemies. There are many kinds of the substratum of the inland water, but in this paper I may confine the subject to one kind of the inland water, namely, the torrent. Nevertheless, I will not consider the current of the water, one of the most characteristic property of the torrent, for a while, and will concentrate my attention only on the substratum itself.

The substratum is not so simple even in the torrent. It is rather most complicated in the torrent in all kinds of the inland water, if the materials, of which the stream bed is composed, are morphologically considered. But it is also simplest, on the other

hand, in so far as it is considered from the vegetation which grows on it, and which usually consists of algae only, covering rocks and stones. And in this respect the stream bed may be ~~considered~~ contrasted with the barren, rocky ground of the mountain summit, where lichens only grow.

Let us consider, in the first place, a kind of the substratum which is composed of some fine ~~substance~~ material as the silt or the mud, and has a homogeneous, evenly stretched surface, offering no shelter or no concealing place. Even if ~~there is~~ provided with plenty of food, such an open place is very dangerous for such weak animals as mayfly nymphs against their enemies. They have not any weapon as ~~does~~ the crab nor any shell ~~in which they~~ to conceal themselves as ~~does~~ the mussel or the snail. Perhaps they can live in such an open place, if they can move about as ~~speedy~~ speedily as their enemies move. But the substratum here discussed is such a substratum that is too soft to resist against their vigorous crawling or their swift running, but permits them only to perch quietly upon its surface.

There remain only two ways for the maintenance of their lives in this dangerous situation. Fortunately, the ~~substance~~ material of which the substratum is composed is soft enough. Then one way is to abandon the occupancy of the surface and to burrow and conceal themselves into the substratum, and this has been succeeded ~~in~~ with the nymphs of the burrowing form, belonging to the families Ephemeridae

and Potamanthidae. Another way is to gain the swift locomotive faculty by clearing the surface of the substratum and by swimming. This has been achieved by the nymphs, which take the stream-line form in their general appearance as represented in the families Siphlonuridae or Baetidae.

~~Then~~ We suppose that the ~~substance~~ material, of which the substratum is composed, becomes more and more coarse, ~~or large in its dimension~~. This change is necessarily accompanied ~~with~~ by the change of the environmental condition. But, on the other hand, this change also signifies the change of the topography of the surface of the substratum from the homogeneous, evenly stretched surface of the mud or the silt deposited, for instance, on the calm ~~lake~~ pool bottom to the irregular surface of rocks and stones which are rolled and heaped on the bottom of the mountain torrent. Of course the curvature of each particle or grain of the surface becomes smaller in proportion as it becomes ~~larger~~ greater in its dimention, if it is considered as an ideal ball. But when it becomes ~~larger than~~ greater beyond some limit concerning the stretch of the legs of mayfly nymphs, they must perch on ~~or attach to~~ it, ~~either~~ whether it is a pebble or a stone. In such a change of the environmental condition, what advantage is expected from a stream-line form with its perching legs, without considering any current of the medium?

On or among ~~the~~ stones or ~~the~~ rocks the dorso-ventral flattened forms, or the limpet-like forms seem to be far more suitable for the occupancy of the surface than

the stream-line forms. Because they do not perch on but stick to the surface, and do not ~~crawle slowly~~ swim but glide swiftly ~~and easily~~ upon it, ~~probably utilizing the surface tention of the water,~~ if the surface is smoothed by the erosion. Moreover the dorso-ventral flattened forms ~~are able~~ enable them to conceal themselves easily in the crevice of the rock surface or the space between the overlapping rocks and stones. And where there is a strong current, it is evident that these forms are more effective. These forms are represented in the nymphs of the families Leptophlebiidae and Ecdyonuridae, especially well respresented in the latter family.

Life forms and habitat segregation in mayfly nymphs

I shall not touch upon the question which of these three forms is the most ancestral one in the phylogeny of the order Ephemeroptera. But if any mayfly nymph must ~~take~~ get its food, consisting in materials mainly of the plant origin, in the inland water and at the same time must keep secure itself as much as possible from its enemies, as already mentioned, then the burrowing form prefers such a bottom condition that enables it to live a burrowing life, while the stream-line form prefers such a bottom condition that enables it to live a perching and swimming life, and at last the dorso-ventral flattened form prefers such a pebble, a shingle or a boulder

which enables it to live a sticking and gliding life, whether the current may be rapid or slow as I shall explain in the subsequent pages.

If these phenomena are originated from the necessity of occupying the habitat for any animal in order to live its life, then the habitat segregation through the differentiation of the structure is, in its contents, no more than the differentiation of the life form itself which I mean. Therefore the habitat segregation through the different forms of mayfly nymphs as mentioned above, means that such is the differentiation of the life form of mayfly nymphs. Such differentiation would have been accomplished in the ancient age in such an archaic order as Ephemeroptera, and it is to be interesting that such differentiation corresponds with the present system of the taxonomy of mayflies, based upon primarily the structure of the imagines.

Distribution of life forms of mayfly nymphs in the torrent

Next I shall have consider the distribution of the life forms of mayfly nymphs in the torrent. Are they distributed at random or orderly? In the mountainous country as Japan, a river may be divided into two geographical or physiographical sections, namely the mountainous section and the plain section. The mountainous section is characterized by the predominance of the erosion by its water, and the plain section is characterized by that of the sedimentation by its water, though this classification is very rough and the sedimentation in the mountainous section or the erosion in the plain section is recognized in some degree.

landscape.

And this may be inevitable if we try to classify a river into some sections, based upon the 'Landschaft'.

But when we consider this from the distribution of the material substances, of which the substratum is composed, large boulders are almost confined to the mountain section, and where the river flows out from the foot-hill, there are still deposited many pebbles and shingles. Then the more the river flows seaward, the more exclusively material the substances, carried and deposited by the water, diminishes in its particles the dimention, corresponding to such changes of the river that the velocity of its current is more and more decreased, though the volume of its water is continuously increased. And as the distribution of the life forms of mayfly nymphs should correlate with the distribution of the habitat, the burrowing life form and the swimming life form may be distributed even in the typical mountain section if their proper habitat condition still exists in it, whereas the gliding life form may be distributed in the plain section in so far as there exist still pebbles and shingles.

But the distribution of such habitats or life forms are in reality determined by the velocity of the current, so I consider a cross-section of the river where it meanders as already Shelford* did. Then the material substances, of which the substratum is composed, is arranged from small to large in its particles dimention according to the increase of the velocity of the current, and with this the burrowing and swimming life forms will succeed to the gliding life form, but this is indeed pedematic. Where the different habitat conditions intermingle with each other, there the

* Shelford, V. E. 1913 Animal communities in temperate America, p.107..

different life forms [illegible] they have [illegible] by nature. It is considered that the gliding form [illegible] not [illegible] out the swimming life form totally, as this form and the gliding life form are into the [illegible] [illegible] of the [illegible] [illegible], and there may be some suitable place between the gliding [illegible] where the swimming life form [illegible]. Thus it is evident, as already mentioned, that the swimming life form becomes unfavorable with the increase of the velocity of the current, thus the predominance of the gliding life form among the inhabitants of the rapid mountain torrent is very natural.

Convergence and divergence of life form of mayfly nymphs

In this respect, the current or the velocity of the current as an environmental factor must be considered again, in the torrent, and here we can understand the divergence among the life forms originally belonging to the same category as well as the convergence among them originally belonging to the different category. Thus if the convergence and divergence imply the differentiation of the life forms, however small, they must be attended with the habitat segregation in the same degree. If we consider them from the structural standpoint, it is natural that they ~~are~~ correspond with the differentiation of the genera among the same family or of the species among the same genus.

For instance, in the different genera among the family Siphlonuridae, which is typical of the streamline form or the swimming life form,

the genus *Ecdyonurus* [illegible] in its distribution limited to the less rapid current [illegible] occurs into the lower courses of the mountain stream, while the genus *[illegible]* is said to prefer the swifter current occurring into the upper courses of the mountain stream than *Ecdyonurus*, and the genus *[illegible]* is sometimes found in the still swifter current than *[illegible]*. Among the species belonging to the family Baetidae, *Baetis thermicus* is one of the strongest species to stand against the velocity of the current in Japan and is found even among the large boulders of the mountain torrent. Although its structure is still the stream-line form, it seems to sacrifice its swimming ability as it must cling to the rock surface firmly, as already discussed by Dodds and Hisaw.* But in this respect, the endemic genus *Baetiella* of the same family is most curious, for *Baetiella japonica* withstands the rapidest current by spreading its legs and sticking to the rock surface as in some species of the family Ecdyonuridae. And, the fact that it has lost completely its median caudal filament seems to exhibit a convergence between this species and *Baetis bicaudatus* in Colorado studied by Dodds and Hisaw** as well as a convergence between this genus and the genus *Epeorus* of the family Ecdyonuridae, also the inhabitant of the rapid current. But *Baetiella*, probably derived from the clinging *Baetis*, can not glide on the rock surface as *Epeorus*, though it can stick firmly on it, so that in its habit it rather tends to converge to that of another inhabitant of the rapid current such as represented in the larva of the different family, Blepharoceridae.

In the family Ecdyonuridae, too, which is characteristic of the gliding

* Dodds, G. S. and Hisaw, F. L. 1924. Ecological studies of aquatic insects. I. Adaptations of mayfly nymphs to swift streams. Ecology, [illegible]

** Ibid., p. 149.

life form, [illegible] [illegible]

condition. If we consider the distribution of the [illegible]

as a criterion of the [illegible] caused by the rapid current, we take at once the genus *Epeorus*. For this reason [illegible] it is not an [illegible] inhabitant of the rapid current, but we have to exclude the hygropetric [illegible] as an exception. If we consider the [illegible] first [illegible] to be a criterion of the same kind, then we may take some species of the genus *Epeorus* and *Rhithrogena* as equivalent ones. But *Rhithrogena* is not exactly the [illegible] of *Epeorus*, or in other words its life form is not the same as that of *Epeorus*. *Rhithrogena*, which is morphologically not so flattened as *Epeorus*, or does not so stretch its legs as *Epeorus* and is rather similar in its general appearance to some species of the genus *Paraleptophlebia*, is also an inhabitant of rather smaller stones as *Paraleptophlebia*. That is to say, *Epeorus* seems to occupy larger stones than *Rhithrogena* chooses for its habitat, if the velocity of the current in these two habitats is in equal strength.

The genus *Cinygma*, which is closely allied to *Rhithrogena*, is also distributed in the substratum which is composed of the smaller stones as in *Rhithrogena*. Therefore we can classify the gliding form further into two life forms according as the substratum is composed of the large stones or the small stones. Then it seems that the family Ecdyonuridae is also classified at least into two main groups corresponding to the classification of the life form. One group is composed of the genera *Ecdyonurus* and *Epeorus*, and the unique *Bleptus fasciatus*, the only hygropetric mayfly nymph hitherto known in Japan, seems to be related to such a species as *Epeorus curvatulus*, which is able to crawl skillfully when the condition of the substratum is not suited for gliding. The other group is composed of the genera *Cinygma* and *Rhithrogena*.

In which of these two groups the genus *[illegible]* belongs is still doubtful, as I have not separated with nymphs of this genus except only one species, [illegible]. [illegible] is distributed exclusively in the spring or the spring-fed, slowly flowing rivulet, the bed of which is constituted mainly of fallen leaves.

And in each of these two groups the differentiation is recognized in their structure as well as in their habitat segregation arranged by the velocity of the current. As a consequence *Epeorus* and *Rhithrogena*, the rapid current inhabitants, are distinguished from *Ecdyonurus* and *Cinygma*, the slow current inhabitants. Now I shall convince myself of the validity of separating these two groups from another standpoint which is concerned in the very important habit of the mayfly nymphs, namely the method of their transformation to the subimagines. This means the essential change of the habitat character, ~~from water to air, so that~~ or the change from the aquatic life to the terrestrial life.

Types of the transformation of mayfly nymphs to subimagines

There are three types of the transformation from nymphs to subimagines. The first type: nymphs which are the burrowing life forms as *Ephemera* and *Potamanthodes* come out of their habitats and float to the surface of the water for transformation. Subimagines emerge, floating at the surface and fly away. ~~This seems to be the only one method adopted by them.~~ The second type: nymphs which are the perching and swimming like forms as *Ameletus*, namely

[illegible] together to the side of the stream over [illegible] of a [illegible] or a [illegible] in the shore to the surface of the water or a [illegible] [illegible]. Here subimagines emerge leaving the numerous skins as they attached to the surface of the stone. And at last the third type [illegible] belonging to the genus [illegible] and *Epeorus*, a group of the gliding life forms correlated with the large stones as their habitats, remain as they stick to the submerged surface of the boulder, even when ready for transformation. Therefore subimagines achieve to emerge under the water, leaving the cast skins on the surface of the boulder and fly up in the air as soon as they float to the surface of the water themselves.

But it is worthy of mention here that *Cinygma* and *Rhithrogena*, another group of the gliding life forms correlated with the small stones as their habitats, do not perform their transformation by this method, but by the second method, though in *Baetiella*, one of the typical rapid current inhabitants belonging to the family Baetidae, subimagines emerge also by the third method. Is it not dangerous to emerge floating at the surface of the water in such a rapid and turbulent current as in the mountain torrent? Is it not to be inferred that the same method of their emergence in such different genera as *Epeorus* and *Baetiella* means the same modification of their habits caused by the rapid current? and, for these reasons, *Rhithrogena* is not so successful in the rapid current as *Epeorus* or *Baetiella*? But how can we explain [illegible] which also emerges by the third method, though it is a slow current inhabitant? For example, *E.* [illegible] is distributed not only in the calm side of the stream but

[illegible] Epeorus [illegible]

[illegible] its life form.

These stones are evidently accumulated by the action of the waves, but the primary necessity for E. yoshidae is in these stones and not in the nature of the waves. as primary adaptation.

It seems to me that the method of convergence is not an adaptations to the velocity of the current but is the consequence of the life forms, and the dorsoventral flattened Ecdyonurus and Epeorus with their wide-stretched legs are originally the life forms which corresponded to sticking and gliding but not to "rasping" so that not to the first and second method of convergence. And this explanation will be also applicable to the case of Bostrichia. And here we shall consider the relation between Epeorus and Rhithrogena once more. The enlarged first gill-lamellae which are formed in some species of Epeorus, formerly recognized as the genus Iron by this morphological character, and in Rhithrogena, will be evidently a convergence on the rapid current. But such a convergence of one organ among different genera does not means that they are always equally successful in every grade of velocity of the current. The morphological inferiority of Rhithrogena to Epeorus (Iron), in the increasing velocity is already discussed in detail by Dr. Hora*. Although I recognized the fact that the large stone inhabitant Epeorus (Iron) is distributed in the swifter part of the current than the small stone inhabitant Rhithrogena, is due to [illegible] the former in its structure is more effective to resist against the washing mechanism of the current than the latter, I cannot help assuming

* Hora, S. L. 1930. Ecology, bionomics and evolution of the torrential fauna. Phil. Trans. Royal Soc. London, Ser. B, vol. 218, pp. 189–190.

at the same time, the fact that there are distributed more large stones in the swifter part of the current than smaller stones. Thus I consider this position [illegible] understood only as another example of the life form theory, or the structure—habitat correlation. Thus considering from the life form, it is evident that Cinygma and Rhithrogena belonged to a life form group different from that of Ecdyonurus and Epeorus, and as there are found no direct connection between these two groups, Hora's diagram* illustrating the evolution of the nymphs of the family Ecdyonuridae must be revised.

Position of the nymphs of the family Ephemerellidae

Here I shall consider the life form of the nymphs of the family Ephemerellidae, untouched in the preceding discussion. Suppose them as those of the surface dwellers of the substratum in their origin. But they can neither swimming nor gliding as they are neither true streamline forms nor [illegible] flattened forms. They are relatively stout built in their general appearance, with enlarged ventral surfaces and are clumsy sprawling creatures in their activities. At least some large-sized species among them as Ephemerella ingens, for example, may take animal food, judging from my field experiences. As these characters are quite different from those of other mayfly nymphs, it seems to me that these belong to the [illegible] life form of inferior swimming nymphs.

* Hora, opt. cit., p. 191.

[illegible] in the slow current. loose pebbles or gravels [illegible] but they are used to hide [illegible] in the débris or the [illegible] between these small stones, and in one respect they [illegible] a step towards the [illegible] life form. Large-sized species such as E. trispina or E. basalis are often found on the [illegible] of a boulder in the rapid current. but as they are also found among the smaller stones, their life form seems to be connected with the large stone not so closely as in the case of ~~such a torrent inhabitant of the rapid current as~~ E. [illegible] or Baetiella. Perhaps the stream-bed, on which boulders lie, is also one of their habitats, where the velocity of the current is reduced and at the same time more or less small stones as well as various kinds of débris are deposited. And if such is the life form of the nymphs of the family Ephemerellidae, it is noticeable that it resembles rather the life form of some dragonfly nymphs in the torrent, for instance, those belonging to the subfamily Gomphinae or the family Epiophlebiidae.

The nymphs of the family Ephemerellidae were classified into some genera by some authors but in recent years Needham and Traver again united some genera into one original genus Ephemerella and I* followed their classification in the preceding paper. But [illegible] from their life forms it seems to me that there are at least two groups in the Japanese species of the genus Ephemerella as above mentioned, namely one group being composed of the more or less large stone inhabitants distributed in the more or less rapid part of the current as E. trispina or E. basalis: the other group being composed of the more or

* Imanishi, K. 1937 Mayflies from Japanese torrents. VII. Annot. Zool. Japon. [illegible]

[illegible] small [illegible] distributed [illegible] [illegible] as [illegible] and almost all other small [illegible] species. Then is there any morphological differentiation corresponding with the [illegible]? I ~~am~~ wish able to treat such a morphological differentiation as follows:

	Species of the [illegible] group	Species of the [illegible] group
In the nymphs	Frontal horns present.	Frontal horns absent.
	Fore femur flattened, with spines on its anterior margin.	Fore femur not flattened, [illegible] spines on its anterior margin.
	Knee spines present.	Knee spines absent.
	Tail fringed with dense hairs from the base to the tip.	Tail with whorls of spines at each joining; if hairy, only on its distal portion.
In the imagines	Caudal prolongation of ~~Axillary cord without caudal~~ scutellal lamellae absent ~~prolongation~~.	More or less developed caudal prolongation ~~Axillary cord with more or less~~ of ~~scutellar~~ scutellal lamellae present ~~developed caudal prolongation~~.
	In the male, third joint of the forceps long.	In the male, third joint of the forceps short.

These are the differentiation of life forms of the nymphs of Ephemerella in so far as the Japanese species I have examined concerned. I will not claim at present that these characters are sufficient to recognize these two groups as different genera but it is doubtless that there is a step representing the differentiation of the forms caused by the change of the environmental condition. [insertion above line: [illegible] corresponds to]

I* have already reported in one of my preceding papers that the enlarged first gill-lamellae are not the sufficient character separating the genus [illegible] from [illegible]

* Imanishi, K. 1934 Mayflies from Japanese torrents V. [illegible]

by the existence of *Epeorus* species, the intermediate ... which possess either large or small first gill-lamellae. Those species with the enlarged first gill-lamellae among *Epeorus*, then, are an example which represents a step of the differentiation among the same genus toward the increasing velocity of the current.

But is there not any person who says, *Epeorus* with small first gill-lamellae is derived from that with large first gill-lamellae by differentiating toward the slower current? There is some aquatic insect which is distributed only in the rapid part of the current and is not traced to the slow current in its origin as the larvae ~~nymphs~~ of Blephaloceridae (the different family). But I consider that in mayfly nymphs the more specialized habitat corresponds to the more specialized life form and also the more generalized habitat corresponds to the more generalized life form. If it is admissible that the more specialized structure is derived from the more generalized structure, and the contrary is not right in general, then that the more specialized habitat is occupied later ~~after~~ the specialized structure is differentiated from the generalized structure, is also to be admissible. If it be true, the differentiation of life form here discussed is always directed toward the maximum velocity of the current.

I will summarize [illegible] above mentioned ~~notes~~ in a diagram accompanying [illegible] paper) (and to represent this relation in the following discussion notation) but will note here once again that the differentiation of life form should be arranged according to the respective life form group, for instance, *Ecdyonurus* → *Epeorus* → *Epeorus* with enlarged first gill-lamellae or *Cinygma* → *Rhithrogena* or *Ephemerella nigra* group → *Ephemerella trispina* group, etc.

Synusia* and life zone

I will finish this paper by considering the distribution of mayfly nymphs from the ecological standpoint. Here I wish to utilize the term 'synusia,' which means a community defined by the life form in plant ecology, to animal ecology, though in this case also its meaning needs to be modified or supplemented to a certain extent. It has been recognized above that there are four main life form groups in Japanese mayfly nymphs, namely, the burrowing life form, the perching and swimming life form, the sticking and gliding life form and at last the concealing and sprawling life form of the family Ephemerellidae. Are these four life form groups immediately recognizable as representing four synusias if we are to isolate the actual distribution of each life form group as an object of our field study, from the biotic community as a whole which consists of so many overlapping synusias?

But I consider, the concept of a synusia is only relative to the biotic community as a whole. We may recognize four synusias according to four life form groups as above-mentioned, but as we have already recognized two different life form groups in the gliding life form, then we may also recognize two different synusias according to these two different life form groups. On the other hand, we may recognize that all life forms of mayfly nymphs constitute a synusia together with other aquatic insects or invertebrates of the stream bed, because the life form of mayfly nymphs is more closely related to those of the other aquatic insects or invertebrates than any other life form, for instance, the life form of the fish. Moreover, we may recognize these aquatic invertebrates inhabiting the stream bed together with the

* Imanishi, K. 1937. Community classification and community analysis (in Japanese). Geog. Rev. Jap., vol. 13,

[illegible] vertebrates.

When such a life form group of wide range is considered as constituting a synusia, there is [illegible] that the stream bed inhabitant belongs to only a subsynusia, and the inhabitant [illegible] to a subsynusia of a subsynusia? I do not intend to attempt such a case as this here, but I will continue using the old term 'life zones' with some modified meaning, to a part of a synusia which is segregated by the different life form groups. Then the terrestrial part and the aquatic part may be two different life zones if these two are covered by one synusia. (Note) Various life zones may be recognized which are arranged according to the increasing velocity of the current, if the stream bed is considered corresponding to one synusia. Therefore, in the distribution of mayfly nymphs, too, each life form group is considered as representing substratum life zones in the torrent. Furthermore, even in the same life form group, the differentiation corresponding to the change of the environmental condition may also be recognized as a series of life zones which segregate the same synusia. For instance, one of the series of the gliding life form is [illegible] as such a series of life zones as Ecdyonurus → Epeorus → [illegible] developed gill-lamellae. And at last we will be able to

[illegible] → Species habitat → Species constitution → Species name.

—1974

There are the relations between life forms, animals and life zones. It is evident to say that such a life environment can be recognized as one only because every animal has a stable form or a definite structure. And a more discriminated one closely such a life environment is, as a rule, correlated with the structural discriminations as well as the structural affinity among the animals, or it may be said that the system of the biotic world itself is constituted basing upon the structural discriminations as well as the structural affinity among the organisms. Then taxonomy, which aims to study the structural differentiation as well as the structural affinity, should be properly recognized as the very science which is indispensable in the synecological studies.

(to be continued)

Is there any person who say Epeorus is derived from Iron by means of the adaptation of more slow current. There are some aquatic insects which are distributed in rapid currents and is not traced to the part of the current, side flow. But I consider that in mayfly nymphs the more specialized habitat corresponded to the more specialized life form, and the more generalized habit corresponds to the more generalized life form. If we admit the more specialized form is derived from the more generalized form, the more specialized habitat is gained after the generalized form differentiate to the more specialized form is also admissible. It seems to me, series of habit and life form parallelism is directed toward the maximum velocity, and therefore the life form series is directed : Ecdyonurus → Epeorus → Epeorus (Iron) or Cinygma → Rhithrogena.

These discussion I arrange in the following table

habitat	life form family forming the synusia	differentiation by the environment		
over or on surface	Siphlonuridae	Siphlonurus	Ameletus, Isonychia	
		Dipteromimus		
	Baetidae	Baetis	Baetis	(Baetis)
		Cloeon		
on surface	Ecdyonuridae	Cinygma	Rhithrogena	Bactiella
		Ecdyonurus	Epeorus	Epeorus (Iron)
		Heptagenia		
	Leptophlebiidae	Paraleptophlebia	Paraleptophlebia	
		chloroterpes		
	Ephemerellidae	Ephemerella	Ephemerella	(Ephemerella)
under surface	Ephemera	Ephemera		
		Pothamanthodes		

These facts are also found in the case of Ephemera.

I have already reported that the enlarged first gill lamellae of the preimaginal stage from is not sufficient for separating this genus from Ephemera, by the existence of a Ephemera dicaudata, in which individuals possess both large and small lamellae, either large or small first gill lamellae. Then, I do not [illegible] the genus from Species with its largest first gill lamellae among the Ephemera offer also an example of the same genus which represents a step of the differentiation among the same genus toward.

*But in this case it is necessary the meaning needs to be modified or supplemented to a certain extent.

Synecological

Symsia and life zone

I will finish this paper by distribution of the mayfly nymphs from synecological standpoint. Here

At last we consider the above mentioned discussion the

For this purpose the term Symsia, means the same life form groups in the plant ecology, to the animal ecology*. I wish to apply the terms

There have been recognized only four main life form groups in Japanese mayfly nymphs, namely, the burrowing life form, its swimming and perching life form, its gliding life form and the crawling life form of the family Ephemerellidae. These four life form groups immediately corresponds with four symsiae. nothing but four symsiae if we consider the distribution of each life form groups as a or as an isolated community of social phenomenon in the biotic society. or the biotic community proposed by Shelford and Clements.

But the conceipt of symsia is only relative against this concrete biotic society. We may recognize the symsiae of mayfly nymph as above, but we may also recognize the entire mayfly nymphs forming a symsia with or without the other animals of the equal situation. On the other hand we have already recognized the two separate life form groups in the gliding life form. These are also respectively distinct symsiae. On the other hand we may recognize the entire mayfly nymph forming a symsia together with the other aquatic animals of the heterogeneous situation because these animals more intimately related with each other and did not occupy the same situation.

judged from the nymphal fauna — It seems to me

nymph which I have acquainted with there are more many specimens in the Kyoto district and in Northern Japanese Alps, especially species belonging to the genera Ephemerella and Baëtis. They are most small-sized for a great part and may be remained to describe till when their life history is ascertained.

In this paper deals with family Baetide.

Six new species will be described, in which fore species belong to the genus Ephemerella and two belong to the genus Paraleptophlebia. On the genus Baetis I wish to note only one species, viz Baetis thermicus Uéno, which seems to distribute very widely in our empire, in horizontally also in vertically, also in seasonal and definitely overwhelm in number the other species of the same genus in every torrents I have examined, although its

Ephemerella =関シテハ Dr Ueno described three new species

1. Note on the distribution

life-form ト habitat トノ correlation.

1. Notes on the life-form of the mayfly nymph and
2. habitat ノ distribution .... Ecdyonuridae ヲスル.
3. may flies ノ distribution ....
4. conclusion of this note .... definite zone ヲ[illegible]

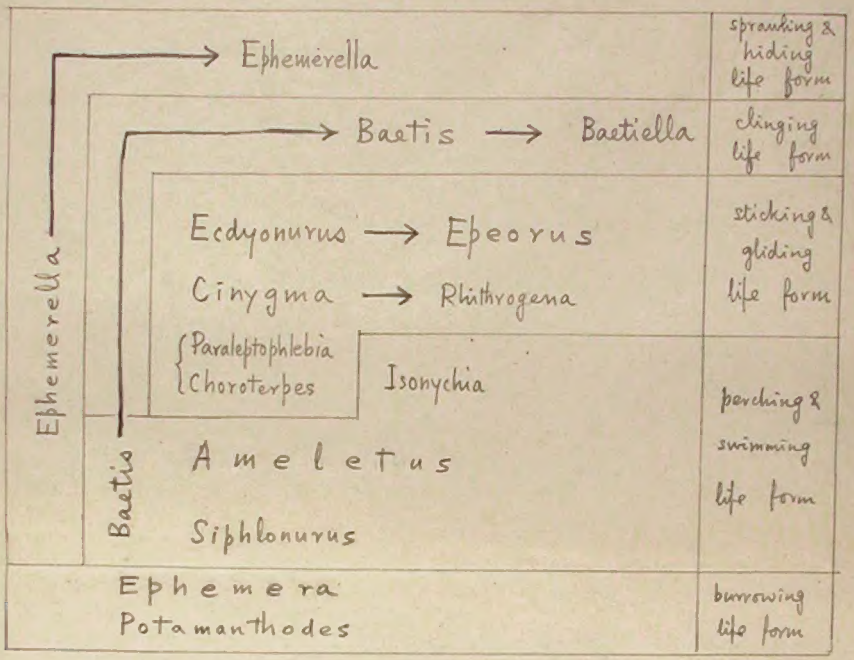
2. Note on the distribution (continued)

1. altitude ニ対スル吟味
2. in Northern Japanese Alps
3. season ニ対スル吟味
4. conclusion of this note .... 水[illegible] life zone ニヨル, [illegible] parallel.

3. Note on the distribution (continued)

1. river type ニ対スル吟味
2. in Northern Japanese Alps
3. in Northern Japan
4. conclusion of this note

Ecdyonuridae ノ[illegible],
succession, [illegible], [illegible] river type.


Ephemerella
Ephemèrella
Baetis → Baetiella
Ecdyonurus → Epeorus
Cinygma → Rhithrogena
{Paraleptophlebia
{Choroterpes
Isonychia
Ameletus
Siphlonurus
Ephemera
Potamanthodes
sprawling & hiding life form
clinging life form
sticking & gliding life form
perching & swimming life form
burrowing life form